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Ghaley, Bhim Bahadur; Montesino San Martin, Manuel; Porter, John Roy

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DEPARTMENT OF AGRICULTURE AND ECOLOGY
FACULTY OF LIFE SCIENCES
UNIVERSITY OF COPENHAGEN

Emergy signature as a basis for sustainability valuation of agro-ecosystems

Bhim Bahadur Ghaley[1)], Manuel Montesino San Martin [2)], John Roy Porter[3)]

[1,2,3] Department of Agriculture and Ecology, Højbakkegård Allé 30, 2630 Taastrup, University of Copenhagen, Denmark

[1)]Email: bbg@life.ku.dk

1. Background

- Humans depend on the ecological resources for the inevitable needs of food, feed and energy
- Human 'engineered' ecosystems have resulted in adverse impacts on the ecosystems
- Agro-ecosystems constitute over 37% of the earth's surface (Porter et al., 2009)
- Agro-ecosystems are biggest contributor to the worsening ecosystem service provision
- Reduction in the capacity of the ecosystems for provision of ecosystem services (MEA, 2005)

2. Problem formulation

- Ecosystem services are integral to the ecological sustainability and the economic prosperity
- A renewed perspective towards a sustainable society (Rydberg & Haden, 2006)
- Need for holistic accounting procedures to account for economic, social and ecological costs
- Emergy analysis (Odum & Odum, 2006) takes account of the environment and the economic inputs

3. Objective

- Assess emergy input in a novel food and energy production (CFE) system compared with conventional wheat production system in Denmark
- To evaluate the sustainability of the two production systems based on emergy indices

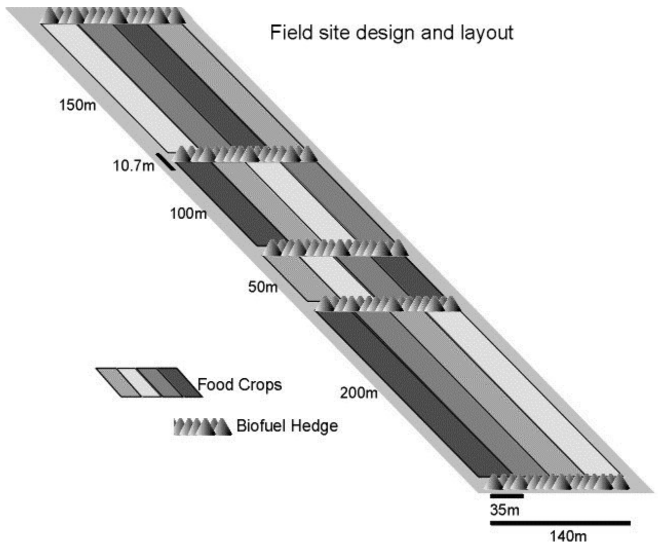


Fig.1: Layout of combined food and energy production system (CFE) in Taastrup in Denmark

Fig.2: Side view of biomass belts of CFE in Taastrup in Denmark

4. Materials and methods

- Emergy analysis steps (Odum & Odum, 2000; Brown et al, 2004)
  - Setting up system boundary after which inputs and outputs crossing the boundary are quantified
  - Inputs are converted into a common currency of solar emjoules based on transformity coefficients
  - Assessment of the fraction of renewable, non-renewable, purchased resources
  - Use of emergy indices (EYR, EIR, ELR, ESI, EFR) for sustainability valuation

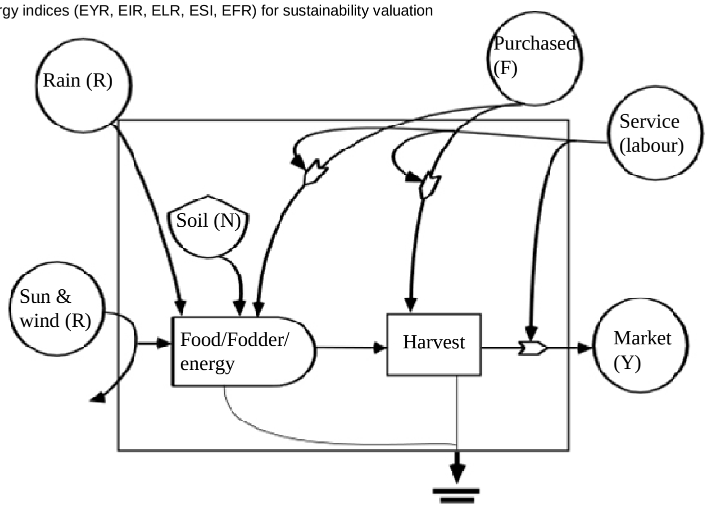


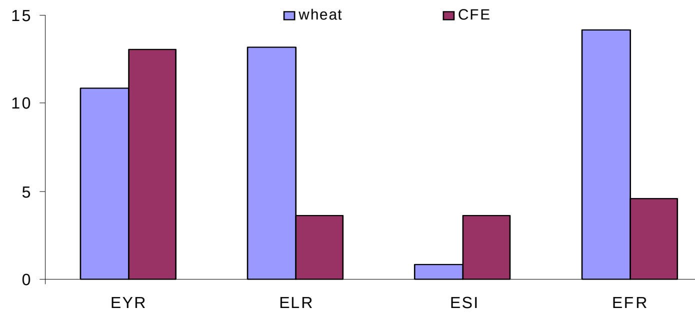
Fig.3: Illustration of main emergy flows and their interactions in combined food and energy system (CFE) in Taastrup in Denmark

5. Results

Table 1: Comparative emergy indices in conventional wheat and combined food and energy systems of production

Emergy Indices	Parameters	Conventional wheat	CFE
Total exported emergy (J ha^{-1}year^{-1})	T	1.76E+11	2.80E+11
Transformity (Sej J^{-1})	Y/T	**1.67E+04**	**3.42E+03**
Yield (Sej ha^{-1}year^{-1})	Y	2.93E+15	9.55E+14
Total renewable (Sej ha^{-1}year^{-1})	R	2.07E+14	2.07E+14
Total non-renewable (Sej ha^{-1}year^{-1})	N	3.31E+13	1.79E+13
Total purchased (Sej ha^{-1}year^{-1})	F	**2.69E+15**	**7.30E+14**
Renewable fraction	R/(R+N+F)	**0.07**	**0.22**
Emergy yield ratio (EYR)	Y/F	1.09	1.31
Environment loading ratio (ELR	(F+N)/R	13.17	3.61
Emergy sustainability index (ESI)	EYR/ELR	0.08	0.36
Emergy investment ratio (EIR)	F/R+N	11.22	3.25
Emergy footprint ratio (EFR)	R+N+F/R	14.17	4.61

Fig.4: Sustainability indices in CFE and conventional wheat



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